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ABSTRACT

Given the projection that minorities will constitute 29 percent of new entrants into the work force by the year 2000 and given the downward trend in minority preparation for and participation in science, mathematics, and engineering, the enhancement of minority preparation in science and technology must become a national imperative. This agenda calls for a comprehensive program that addresses the preparation of minorities on all levels. The program calls for (1) reaching out to, enriching, and developing students, faculty, and the community; (2) improving instructional programs at all levels; (3) strengthening historically black colleges and universities and minority institutions; (4) providing special attention to graduate and postgraduate education and research programs; and (5) creating a system of comprehensive assessment and evaluation of existing programs and the proposed program. Objectives of the initiative are to quadruple the number of minority students receiving baccalaureate degrees annually in the physical and life sciences and engineering, from 17,000 in 1987 to 68,000 in the year 2000, and to triple related doctorates received annually in the same period from 389 to 1,200, as well as to quintuple the number of newly qualified minority teachers each year from 6,000 in 1986 to 30,000, with at least 30 percent of this group being mathematics and science pre-college teachers. Nine tables and three figures present supporting data. (SLD)

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Together We Can Make It Work

A National Agenda to Provide Quality Education for Minorities in Mathematics, Science, and Engineering

Prepared by the
Quality Education for Minorities in Mathematics, Science, and Engineering (MSE) Network

April 1992

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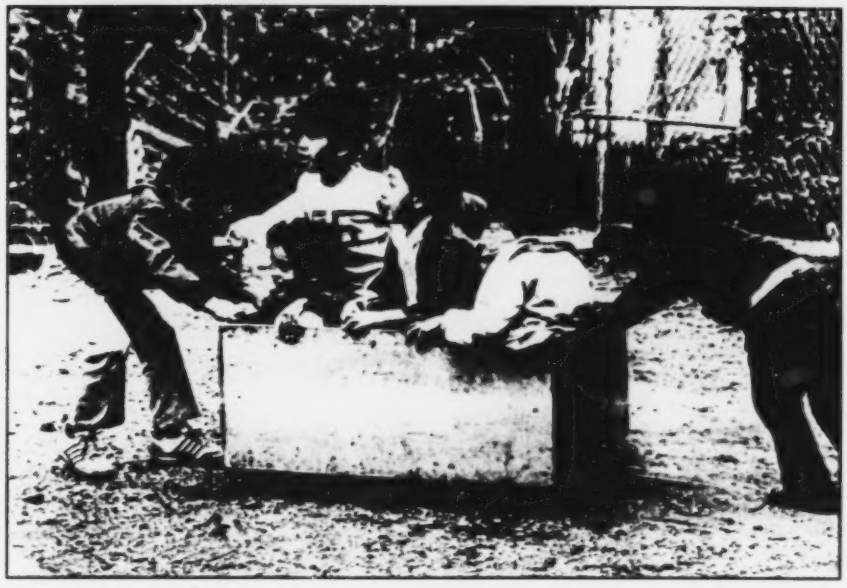

A National Agenda to Provide Quality Education for Minorities in Mathematics, Science, and Engineering

Prepared by the
Quality Education for Minorities in Mathematics, Science,
and Engineering (MSE) Network
April 1992

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MEMORANDUM OF UNDERSTANDING ..... Inside Back Cover

Percentage of Females and U.S. Minorities in Various Population Groups

	Percent of U.S. Citizens					
	Female	White	Black	Hispanic	Asian	Indian
U.S. Population (1986)	51.8	77.5	12.0	7.8	2.1	0.6
Elementary / Secondary Enrollment (1984)	50.0	71.2	16.2	9.1	2.5	0.9
High Scool Graduates (1986)	51.0	74.2	15.8	6.8	3.1	0.4
Undergraduate Enrollment (1986)	52.2	80.7	9.4	5.4	3.7	0.8
Graduate Enrollment (1986)	48.2	87.2	5.5	3.5	3.3	0.3
Bachelor's Degrees (1987)	51.5	87.5	5.9	2.8	3.4	0.4
Sci / Eng Bachelor's Degrees (1987)	39.0	86.0	5.4	2.9	5.2	0.4
Master's Degrees (1987)	51.2	88.2	5.4	2.7	3.3	0.4
Sci / Eng Master's Degrees (1987)	31.4	86.6	3.5	2.8	6.8	0.3
Doctorates (1987)	35.2	89.1	3.8	2.7	4.0	0.4
Sci Eng Doctorates (1987)	26.1	89.5	2.3	2.5	5.6	0.3

Source: Vetter, Betty M. (1989). Professional Women and Minorities: A Manpower Data Resource Service.

Together We Can Make It Work

A National Agenda to Provide Quality Education for Minorities in Mathematics, Science, and Engineering

The Executive Summary

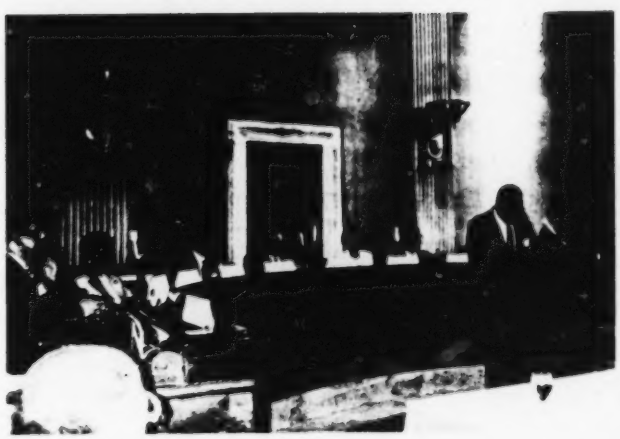
By the year 2000, the American work force will face a critical shortfall of scientists, mathematicians, and engineers, and the nation will be unable to sustain its leadership role and to compete with advantage in the global economy, unless it moves expeditiously to improve the quality of education for minorities in mathematics, science, and engineering.

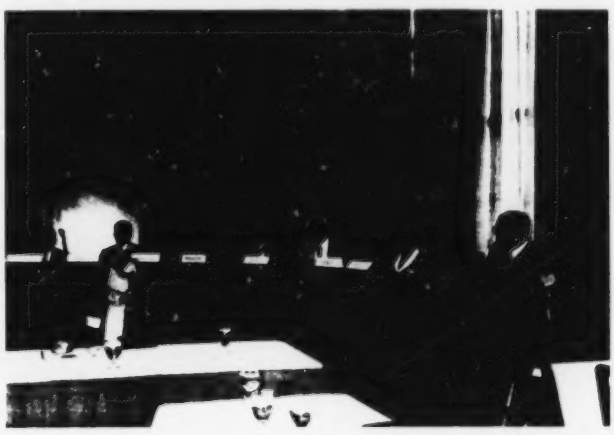
Given the projection that minorities will constitute 29 percent of new entrants into the nation's work force by the year 2000 and given the current downward trend in minority preparation for and participation in science, mathematics, and engineering careers, the enhancement of minority preparation in science and technology becomes clearly not a choice, but an obligation and a national imperative. The nation must move quickly to restructure the process by which it produces, and redouble its commitment to producing a greater number of, minority mathematicians, scientists, and engineers.

Together We Can Make It Work: A National Agenda to Provide Quality Education for Minorities in Mathematics, Science, and Engineering is a national agenda designed by the Quality Education for Minorities in Mathematics, Science, and Engineering (MSE) Network. The MSE Network is a coalition of minority and non-minority educational institutions, school districts, and national science and education organizations throughout the country, collaborating on a plan to improve the education of minorities in these areas. *Together We Can Make It Work* calls for a comprehensive program that addresses the preparation of minorities on all levels, from kindergarten to post-doctoral research. It calls for: (1) outreach, enrichment, and development for students, faculty, and the community; (2) improvement in instructional programs at all levels, with special emphasis on preparing mathematics, science, and engineering teachers; (3) the strengthening of Historically Black Colleges and Universities and Minority Institutions to enable them to enhance their remarkable record in preparing minorities; (4) special attention to graduate and post-graduate education and to research programs; and (5) a system of comprehensive assessment and evaluation of the nation's mathematics, science, and engineering education of minorities, as well as of the Network's program.

Together We Can Make It Work has three achievable objectives: (1) to quadruple the number of minority students receiving baccalaureate degrees annually in the physical and life sciences and engineering, from 17,000 in 1987 to 68,000 in the year 2000; (2) to triple the number of minorities receiving doctorates annually in science and engineering, from 389 in 1987 to 1,200 in the year 2000; and (3) to quintuple the number of minority college students newly qualified to teach who enter teaching each year, from about 6,000 in 1986 to 30,000 by the year 2000, with at least 30 percent of this group being mathematics and science pre-college teachers. The MSE Network plans to achieve these objectives by: (1) bringing together institutions, organizations, and individuals to promote quality MSE education for minorities; (2) forming state partnerships in those states with significant minority populations to help achieve the numerical goals; (3) sharing and disseminating information on the MSE education of minorities; (4) recommending systemic changes that will improve MSE education for minorities; and (5) developing and helping to implement a national agenda of programs and projects to improve MSE educational opportunities for minority children, youth, and adults.

This report presents a blueprint for change in the nation's preparation of minorities in mathematics, science, and engineering. It calls for a coalition of the major institutions and organizations in the public and private sector that determine, rely on, and care about the quality and quantity of minority mathematicians, scientists, and engineers that the nation produces. With an established national agenda, a common sense of purpose, and a strong commitment, *Together We Can Make It Work!*





Together We Can Make It Work

A National Agenda to Provide Quality Education for Minorities in Mathematics, Science, and Engineering

The Challenge

The American work force will face a critical shortfall of scientists, mathematicians, and engineers by the year 2000. This shortfall could have adverse impact on the nation's ability to compete in the global economy. It must be addressed, increasingly, by significant numbers of those groups historically underrepresented in these fields.

Historically, scientists and engineers have been drawn largely from the white male population. However, demographic projections indicate that the white male population is declining, while minority and white female populations are increasing. By the year 2000, it is projected that non-whites will make up 29 percent of the new entrants into the labor force.[1] It is also predicted that, by the year 2000, one child in four will be poor and that one child in three will be a minority.[2]

At the same time, it is the vision of the President of the United States and the nation's governors that by the year 2000 American students will be first in the world in science and mathematics. Current enrollment data show a significant underrepresentation of minorities among Americans enrolled in undergraduate and graduate degree programs in science, mathematics, and engineering in colleges and universities. Further, the retention rate of minorities in these programs is relatively low in comparison to their enrollment. At present, Blacks, Hispanics, and Native Americans comprise 10.2 percent, 7.3 percent, and less than 1 percent, respectively, of the U. S. labor force,[3] but represent only 2.6 percent, 1.8 percent, and 0.4 percent, respectively, of all employed scientists and engineers.[4] Therefore, it is imperative that the nation take extraordinary steps to maintain America's leadership in science and technology by preparing minorities

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[1] William B. Johnston, *Workforce 2000, Work and Workers in the 21st Century*, Indianapolis, IN, Hudson Institute, 1987, p.xx.

[2] *Five Million Children: A Statistical Profile of Our Poorest Young Citizens, 1991 Update* National Center for Children in Poverty (New York, 1991).

[3] Vetter, Betty M., *Professional Women and Minorities*: A Manpower Data Resource Service, Commision on Professionals in Science and Technology (Washington, DC, 1991), ninth edition, p. 127.

[4] *Ibid*, p. 136.

for greater levels of participation in science, mathematics, and engineering in the year 2000. The nation must design strategies to alter the structure of the educational system, in order to produce a significant number of minority mathematicians, scientists, and engineers. It is clear that the current educational system must undergo major reform.

To achieve the QEM Network's MSE goals for the year 2000, as well as the national goal in science and mathematics, systemic changes must take place in mathematics, science, and engineering education from kindergarten through undergraduate preparation, to the way graduate schools prepare minority students for academic and research careers. These goals will require broad-based and significant capacity-building at minority institutions (increased student support, enhancement of research infrastructures, faculty development, and support for faculty research). They also require more supportive environments at non-minority institutions currently enrolling, but not necessarily graduating, significant numbers of minority students in MSE fields (more minority faculty and staff, increased financial support, faculty mentoring, and networking with alumni). In short, these goals require a national investment in the future of America through support that will significantly increase the participation of minorities in mathematics, science, and engineering.

The Vision

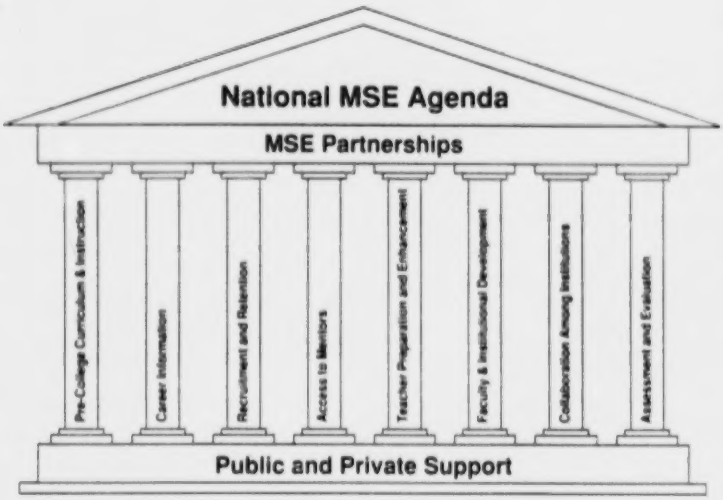
The vision of the Quality Education for Minorities in Mathematics, Science, and Engineering Network is to realize a significant increase in the participation of underrepresented minorities in all sectors of the nation's mathematics, science, and engineering community to a level that is at least comparable to their numbers in the general population and at a pace consistent with the country's shifting demographics.

This vision calls for **a national agenda**, united by an overarching sense of purpose and **built upon** a firm foundation of **public and private support**. That national agenda maintains a strong set of principles that supports it like the pillars of a sound architectural structure.

GUIDING PRINCIPLES

- Motivating and preparing minority students to major in mathematics, science, and engineering disciplines in college requires *rigorous mathematics and science curricula and high quality instruction at the K-12 levels.*

- Increasing the number of minority students in mathematics, science, and engineering requires *improving the dissemination of information and the counseling of students and parents about career opportunities and preparation needed for careers in mathematics, science, and engineering.*



- Increasing the pool of minority students in mathematics, science, and engineering requires *broadening the recruitment and improving the retention of students* in these disciplines.

- Improving the number of minorities entering and persisting in programs in mathematics, science, and engineering must include *a mentorship network* that affords role models all along the educational continuum and in the workplace: formal and informal interaction between students and teachers in elementary, middle, and high school; between faculty and students in higher education; and with mathematicians, scientists, and engineers in industry, business, government, and the corporate world.

- Ensuring the nation's future in mathematics, science, and engineering must be based on a strong commitment to providing the *best quality preparation of teachers in these disciplines and the promotion of teaching as an attractive and worthwhile profession.*

- Increasing the number and quality of minority graduates in mathematics, science, and engineering must involve *greater support for faculty and institutional development at minority institutions.* Given the track record of minority institutions in graduating students in these fields, such support should be aimed at increasing graduate study opportunities, improving teaching, increasing the pool of minority faculty, and enhancing research opportunities and support.

- Promoting quality education for minorities in mathematics, science, and engineering requires that the nation must achieve a high level of *collaboration between educational*

institutions and organizations, national laboratories, federal and state agencies, industry, and business. Non-minority institutions, including major research universities, must provide more supportive learning environments for their minority students.

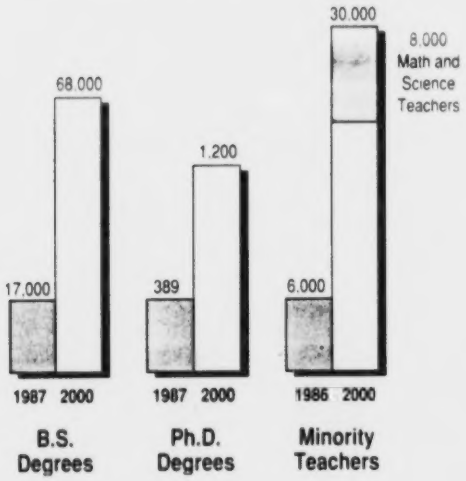
Δ Improving the quality of educational programs and the progress of individual students requires *assessment and evaluation to identify and generalize the methods that work and that meet student and regional needs effectively.*

The Objectives

In order to realize this vision, the MSE Network, working cooperatively and coordinating its efforts with others committed to maintaining the nation's leadership in the global economy, shall assume the leading role, nationally, in achieving the following goals:

- a quadrupling of the number of minority students receiving baccalaureate degrees annually in the physical and life sciences and engineering, from 17,000 in 1987 to 68,000 in the year 2000;

NUMERICAL GOALS FOR THE YEAR 2000



- a tripling of the number of minorities receiving doctorates annually in science and engineering, from 389 in 1987 to 1,200 in the year 2000; and

- a quintupling of the number of minority college students newly qualified to teach who enter teaching each year, from about 6,000 in 1986 to 30,000 by the year 2000, with at least 30 percent of this group being mathematics and science pre-college teachers.

The Strategies

The MSE Network has established a coalition of Historically Black Colleges and Universities, predominantly minority institutions, non-minority universities, school districts, and national education and scientific organizations to launch a plan and a number of nationwide, regional, state, and local initiatives aimed at achieving its objectives and realizing its vision and at ensuring the nation's achieving its goal of being first in the world in mathematics, science, and engineering by the year 2000. This coalition will be expanded to include federal and state agencies, national and federal laboratories, industry (including small businesses), and other two- and four-year colleges and universities.

These strategies include:

- developing *model pre-college instructional programs* at participating institutions to provide quality mathematics and science education for minority students at the K-12 level;
- developing *model pre-college enrichment programs* at member institutions to inform minority students at the K-12 level of and prepare them for career options in mathematics, science, and engineering;
- developing among member institutions *secure pathways* to facilitate the transition of minority students *from high school and 2-year colleges into 4-year colleges and universities;*
- developing model programs at member institutions to provide *undergraduate* minority students early *research experience* with dedicated mentors and role models; and academic enrichment, mentoring, and counseling to enhance their self-confidence, interest, and desire to achieve in mathematics, science, and engineering;
- developing *secure pathways* to facilitate the transition of minority undergraduate students *into graduate school;*
- establishing *state partnerships* among colleges and universities, school systems, federal/state/local governmental agencies, major national laboratories and centers, industry, private foundations, accrediting groups, and professional organizations;

Xavier University (New Grleans) has a series of four pre-college programs (**MathStar** for rising 9th graders, **BioStar** for rising 10th graders, **ChemStar** for rising 11th graders, and **SOAR** for students who have completed the 11th or 12th grades. This comprehensive program, and the hospitable climate in which it is carried out, inspires and motivates high potential students early on to think of themselves as future scientists and medical professionals, and to become academically prepared for later success in these fields.

Xavier's "pipeline" programs "de-mystify" science for students by maximizing their exposure to mathematics and science. The programs are responsive to the needs of the students they are serving; they make experienced teachers available to the students who need these teachers the most; and they make incentives clear to students for pursuing higher education.

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The role of the state partnerships will include, but not be limited to:

1) preparation of an inventory of model programs that exist on the national, regional, state, and local levels;

2) utilization of resources such as the various "Centers of Excellence" and "Science Resource Centers" that have been established by federal and state agencies, private foundations, and corporate groups;

3) participation in the dissemination of information in new areas of knowledge and interdisciplinary programs that relate to instruction and research at all levels in the education system, from pre-college through post-graduate preparation; and

4) securing the participation of representatives from institutions, agencies, and boards that play a significant role in evaluating and providing oversight to high quality programs in mathematics, science, and engineering.

- *identifying, validating, and disseminating* information nation-wide on *promising programs and strategies* for possible replication across the country; and

- developing specific evaluation plans and procedures for *assessing* both *qualitative and quantitative changes* related to the achievement of these objectives.

Assessment of Qualitative and Quantitative Change
Validating and Disseminating Information on Promising Strategies
State Partnerships
Pathways to Graduate School
Undergraduate Research Opportunities
Pathways from High School to College and From Two Year to Four Year Institutions
Model Pre-College Enrichment Program
Model Pre-College Instructional Program

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The Program Design

The program design of the MSE Network operates on the conviction that the nation's educational program in mathematics, science, and engineering is a joint responsibility shared not only by academic institutions at all levels, but also by those who are the beneficiaries of the students that academic institutions produce. It presupposes that academic institutions, business, industry, government, and the community must work together, with a clearly articulated national agenda, toward the goal of ensuring the nation's continued leadership in mathematics, science, and engineering. It is also based on the belief that an effective program must use the holistic approach of establishing a network that brings together all of the major components that affect education. Therefore, although the MSE Network's program design is structured around the various levels and components of academic programs, it emphasizes throughout the need for the involvement of other major constituencies.

"Fundamental to bringing about the changes we advocate is the total restructuring of schools and marshalling of energy and resources of various organizations, agencies, and communities toward the provision of quality education for minorities."

—Education That Works: An Action Plan For the Education of Minorities. Report of the Quality Education for Minorities Project, January 1990.

Outreach, Enrichment, and Development

Outreach and enrichment must be part of a coherent vision that includes model instructional programs at all academic levels, the development of secure transition pathways from kindergarten through graduate school, attention to both cognitive and affective student attributes, and a rigorous system of educational assessment and accountability.

Minority students at all academic levels need outreach and enrichment programs that bring them into the mathematics, science, and engineering career pipeline. In addition, they need general education and the ancillary skills necessary for success in mathematics and science. Thus, educational programs need to be broadly based efforts that actively involve K-12 teachers, college and university faculty, industry, community organizations, and parents in outreach and enrichment activities. These efforts should include a focus on the development of each group's capacity to offer such programs.

Outreach and enrichment activities must complement and enhance instructional programs in schools, colleges, universities, museums, and other educational institutions, and they must evolve with these programs as reforms in mathematics and science education occur. Increased minority representation in mathematics, science, and engineering careers depends on a careful articulation of outreach efforts for students, faculty, and the community that provide immediate enrichment and information for minority students and their parents.

***FAMILY MATH** brings children and family members together in classes where they learn problem solving skills and build an understanding of mathematics through the use of hands-on materials. Classes are offered by teachers, parents, retired persons, or community workers in a school, church, community center or home. Topics include logical thinking, numbers, geometry, probability and statistics, measurement, and estimation.*

*External evaluations have found that, following participation in **FAMILY MATH**, parents gain new confidence in their ability to help their children; children see learning as an active and enjoyable process to be shared with others; and teachers offer classes that are oriented more toward process, discovery, and problem solving. **FAMILY MATH** is a part of the EQUALS teacher education program at the Lawrence Hall of Science, University of California at Berkeley.*

All outreach and enrichment projects need to provide the climate of intellectual and social support for minority students that is found at Historically Black Colleges and Universities (HBCUs) and Predominantly Minority Institutions (PMIs). In addition, there needs to be long-term financial commitment to supporting students individually as well as to supporting and sustaining outreach and enrichment activities.

Student Outreach and Enrichment

A key element of outreach and enrichment efforts should be the identification and recruitment of minority students who can become faculty at all academic levels or who can enter industrial careers in mathematics, science, or engineering. Minority students currently in the mathematics, science, and engineering pipeline, as well as those newly recruited into it, must be encouraged to succeed. This encouragement requires that elementary, secondary, undergraduate, and graduate students have access and regular exposure to highly qualified teachers as well as to viable role models in science and technology-oriented careers.

Pre-college students should interact regularly with undergraduate and graduate students. Students at all academic levels should interact with scientists and engineers in a variety of learning situations. Beginning at the pre-college level and continuing through all academic levels, students must be aware of career requirements, undergraduate opportunities, and graduate school options. As part of these efforts, "Near Peer" mentoring can play an important role—high school students mentoring middle school students, middle school students mentoring at the elementary level.

The MSE Network envisions two major program areas that would span academic levels from pre-college through graduate studies:

- Academic Enrichment Programs
- Information and Awareness Programs

Outreach and mentoring will necessarily involve close working relationships among faculty from elementary school through graduate school, community organizations, parents, and a host of scientists, engineers, and industry personnel who can provide enriching activities.

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Academic Enrichment Programs — At the K-12 level, intervention programs and enrichment activities must complement school curricula and significantly enhance school mathematics and science curricular structures. Minority communities have already developed and tested Pre-college Science Academy Programs, and they must be replicated to serve a larger number of minority students around the United States. Such academies might have Saturday or after-school formats, particularly suitable for younger pre-college students, or they may be developed as summer commuting or residential programs.

Minority students need academies that serve students who have expressed interest in mathematics and science, as well as a larger group of high potential students who have not had much exposure to science. These might include regional science academies that focus on large-scale scientific projects and place minority students at the cutting edge of research. Institutions should establish model academies that provide opportunities to work on, for example, environmental restoration, materials science, engineering design, supercomputing, and earth-observing systems. However, there is also a need for academies that focus on basic knowledge and skills, including tutoring, monitoring of homework, informal mathematics and science activities, computer skills, and development of critical thinking and problem-solving skills.

If science academies are established and sustained, they can provide an infrastructure for long-term outreach to and enrichment of minority students. They should have the direct effect of fostering working relationships among schools, universities, industries, and parents to develop and implement academy programs.

At the undergraduate and graduate levels, minority students need programs that focus on improved research opportunities. Since there is strong evidence that research experiences both retain students in science programs and provide more substantive training, a major emphasis should be placed on science internships for undergraduates. Research opportunities should include science policy as well as research in traditional science disciplines. Research internships should not only become part of the formal instructional program, but should also be developed as outreach and enrichment projects.

***DAPCEP's** (Detroit Area Pre-College Engineering Program) goal is to increase the number of middle and high school minority students who are prepared academically to pursue careers in technical fields. In-school programs emphasize hands-on activities and participation in the Metropolitan Detroit Science and Engineering Fair. Over the years, DAPCEP students have increased their share of Gold Awards in the Fair from 1% in 1976 to 38% in 1991.*

Saturday and summer enrichment activities in 1991 reached more than 2700 students, and about 60 professionals participated in DAPCEP's Mentors Program that same year. Also in 1991, DAPCEP was named by the Business Higher Education Forum as one of the ten best business-higher education partnerships in the country. A recent poll of DAPCEP alumni revealed that more than 70% of the program's graduates enroll in and complete college engineering, science, and mathematics programs.

Summer research experience programs for undergraduates are already well-established and must be replicated to provide more opportunities for minority students. Educators should expand academic-year internships in academic, national, and industrial laboratories to reach a larger number of minority students. They must improve the range of research opportunities for minority graduate students, and industry and national laboratories should develop a variety of research internship programs that complement academic opportunities.

Information and Awareness Programs — For the K-12 level, educators need to develop informational systems that help minority students see the pathways from elementary school to career opportunities, and that also help them understand and value the academic goals that must be achieved for satisfactory progress along these pathways. Whether as part of science academy programs or through parallel outreach projects, minority students must have better access to, and understanding of, academic and career pathways in mathematics and science.

At the undergraduate level, the educational community needs to increase minority student awareness of and access to careers in mathematics, science, and engineering. Outreach and enrichment activities should begin with entering freshmen and continue through the choice of major and into the final undergraduate stages, when they make career and graduate school decisions. These career and graduate school awareness activities should reflect a continuation of, and be analogous to, career and academic counseling provided to pre-college minority students.

Although minority graduate students have been successful in their academic pursuits at the pre-college and undergraduate levels, institutions should improve the general support and career counseling for them as well. Internships and mentoring programs should have career counseling activities nested within them to help minority students become aware of obstacles that they will face in careers and sources of support which they can find to overcome barriers.

Faculty Outreach and Enrichment

The MSE Network argues strongly for the development of outreach and enhancement programs for faculty at all academic levels. These programs should provide a wide range of opportunities, including pedagogical and content enhancement, mentoring, and research experiences for minority faculty who teach minority students. The goals of outreach and enrichment activities must include development of multicultural perspectives and the establishment of formal and informal interactions among K-12 teachers and students and faculty and students in higher education.

Faculty outreach and enrichment programs must parallel and enhance student outreach and enrichment programs. The academic enrichment programs for students must be matched by similar efforts for faculty. The information and awareness activities for students must be augmented and reinforced by faculty programs that enable faculty to guide youngsters through the pathways to MSE careers. The MSE Network sees a need for enhancement in two major faculty program areas, which match the student outreach and enrichment activities:

- Faculty Development Programs
- Mentoring Programs

These programs must span the needs of faculty from kindergarten teachers through graduate school professors.

Faculty Development Programs — As national reforms in mathematics and science education occur, K-12 faculty will require an array of support and enrichment activities. Minority and non-minority teachers of minority students, first of all, must be well-prepared in their specific disciplines in order to provide quality mathematics and science education to their students. Systemic change is essential and will require broad-based teacher education projects. In particular, there is a need for programs that create a critical mass of mathematics and science specialists in every school.

Colleges and universities need to provide research initiation support to minority junior faculty in tenure-track positions, and national laboratories and industry should increase collaborative research opportunities and internships for minority faculty. Junior faculty have to be established in research; then they can be taught how to mentor students.

Pre-college faculty will need enriching experiences in a variety of areas: seminars on the national educational goals and on national recommendations and state mandates for mathematics and science education reform; multicultural and interdisciplinary approaches to teaching science; research; mentoring; assessment; and development of curricular frameworks and materials. Financial support will be needed to create science faculty outreach programs. Released-time must be available to allow faculty to attend enrichment programs and then adopt what they have learned to classroom situations.

Mentoring Programs — Mathematics and science specialists in schools can serve as in-service mentors and provide close support for other teachers in their school. Teacher enhancement programs should be designed to encourage interaction among elementary, middle, high school, and university faculty. As teachers work with their colleagues across grade levels, they will be better able to help students make transitions through grades K-12 and from high school into colleges and universities.

College and university faculty play a pivotal role in the education of minority students, since undergraduate and graduate students go on to careers in science and become teachers at all academic levels. College and university faculties need programs that prepare them to implement recruitment and retention strategies that increase minority participation in mathematics and science programs, including science education. This should include formalized mentoring programs in research, policy, and teaching, so that faculty can help each other and provide training in how and when to mentor minority students, as well as why such mentoring might be needed. Junior faculty need to be encouraged to pursue mentoring activities aggressively. Their mentoring, teaching, and outreach activities should be taken into consideration when determining course loads, promotions, and salary increases.

In all student outreach and enrichment activities, undergraduate and graduate faculty must explore ways to develop and sustain mentoring projects that encourage matching high potential minority students with appropriate faculty. Such programs should be designed to retain these students through graduate school.

Community Outreach

Sustained community outreach requires the combined resources of a strong partnership among universities, industry, schools, and parents. Colleges and universities, working closely with K-12 systems, should clearly articulate to the academic and broader community the goals, objectives, specific expected outcomes, and strategies to increase the number of minority students pursuing careers in mathematics, science, and engineering.

In general, the focus of community outreach must promote an awareness of the critical need for, and the importance of having, more minority teachers and more minorities in technology-oriented careers. An important corollary to this awareness is the fact that educators, in general, need to develop outreach programs to inform students and parents of the variety of mathematics, science, and engineering careers, as well as the pre-college preparation students need to pursue a mathematics, science, or engineering major in college successfully.

The educational community needs to focus more attention on rural areas where outreach projects are made difficult by the wide dispersion of students and their families and by the logistics of transportation to and from outreach programs. It also must reach out to communities that do not have a tradition of community and family education projects and to student populations in which there are high percentages of single working parents who have difficulty attending student-parent outreach activities.

Within communities, there must be a number of alliances formed that can work with universities, schools, and industry. Community organizations, churches, and parent-teacher associations can effectively recruit and encourage youth to become future mathematicians, scientists, engineers, or science teachers. In all community outreach efforts, a broader vision of educational partnerships with industry, museums, national laboratories, and academic institutions must be nurtured and retained.

"The strongest leadership is the leadership of example. It begins at the elemental levels of the family, with efforts that parents can make, such as monitoring homework and supporting local teachers and schools. Community groups such as churches and social organizations also have a role to play."

—Education That Works: An Action Plan For the Education of Minorities, Report of the Quality Education for Minorities Project, January 1990.

Ventures in Education *(formerly Macy programs) is a public school academic program with the following distinguishing characteristics:*

- *high expectations for students and teachers alike;*
- *an upgraded curriculum, including four years of English, math, science, and social studies as well as 2 years of a foreign language;*
- *after-school and summer academic programs for students;*
- *faculty development in new and effective pedagogies;*
- *systematic preparation for college, including preparation for standardized tests and intensive academic guidance.*

Program features include an extended school day; a focus on language, reading, and study skills; Advancement Placement courses in biology, calculus, English, and social studies; and faculty and peer tutoring.

The academic preparation of Macy students in the Class of 1990 far exceeded the national average in several categories: 4 years of English (95% vs 77%); 3 years of foreign language (64% vs 27%); 4 years of math (95% vs 51%); 4 years of science (95% vs 32%); and Advanced Placement in one or more subjects (73% vs 45%). Macy-sponsored students had significantly higher grades in pre-collegiate courses; significantly higher scores on standardized tests than the national averages for various minority groups; significantly higher rates of graduation from high school; and over 90% had enrolled in four-year colleges.

Instruction

The improvement of instructional programs at the pre-college, undergraduate, and graduate levels will enhance minority participation in mathematics, science, and engineering. The MSE Network will strive to promote changes in curricula and methodologies at all of these levels. It will place emphasis on the quality of teacher preparation and enhancement programs and on the sustained involvement of parents, community agencies, and industrial firms.

Pre-College Instruction

The instructional program design of the MSE Network will focus on effecting a number of changes at the K-12 level:

Δ All students must have access to a rigorous mathematics and science curriculum that has sufficient depth to prepare and motivate them to pursue a mathematics, science, or engineering major in college. This should include four years of science, including Biology, Chemistry, and Physics; and four years of mathematics, including Algebra, Trigonometry, Geometry, and Calculus.

Δ Schools should use higher curriculum standards and options like those being proposed by professional organizations such as the American Association for the Advancement of Science (AAAS), the National Science Teachers Association (NSTA), and the National Council of Teachers of Mathematics (NCTM) to revise their programs of study.

Δ Teachers of mathematics and science must be specialists in their disciplines and be provided enhancement opportunities to further develop expertise in their areas.

Δ Teachers and students should have access to a computer network for instructional and/or research applications. The MSE Network will seek support to provide or facilitate such access through its state partnerships.

Δ The teaching of mathematics, science, and engineering must include strategies and pedagogical techniques that accommodate the diverse ways in which students learn.

Δ Pre-college instruction should expose students to laboratory activities, early research experiences, and mathematics and science competitions in order to explore concepts and gain some experience with scientific discovery.

- After-school, Saturday, and summer science academy programs that provide laboratory exercises and hands-on experiences should supplement pre-college instruction in science and mathematics.

- Teachers, parents, counselors, coaches, and other individuals who influence children and youth should be exposed in greater depth to the opportunities and requirements of various mathematics, science, and engineering careers.

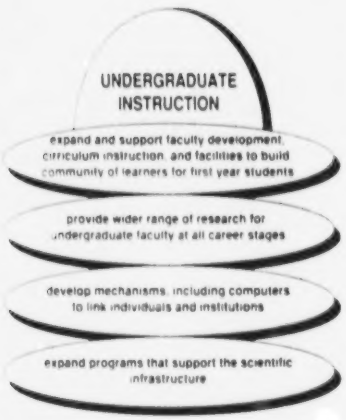
- The education system should recognize undergraduate institutions and liberal arts colleges as an essential resource that can make a unique contribution to the national reform efforts in pre-collegiate science and mathematics education.

Undergraduate Instruction

At the undergraduate level, the enhancement of the learning of minorities in mathematics, science, and engineering must move beyond the provision of special programs to systemic changes in the undergraduate curriculum, requiring special institutional involvement in the nurturing of minority students. The MSE Network will work with two- and four-year colleges and with universities in their efforts to make structural changes in undergraduate instruction, so that more students are nurtured as active learners in supportive communities of students and faculty.

The report of Project Kaleidoscope, *What Works: Building Natural Science Communities*, provides specific recommendations and directions for undergraduate reform:

- expansion of support for faculty development, curriculum innovation, instructional equipment, and science facilities that focus on building communities of learners for first-year undergraduate science and mathematics students, both prospective major and general students;


UNDERGRADUATE INSTRUCTION
expand and support faculty development, curriculum instruction, and facilities to build community of learners for first year students
provide wider range of research for undergraduate faculty at all career stages
develop mechanisms, including computers, to link individuals and institutions
expand programs that support the scientific infrastructure

- provision of a wider range of research and enhancement opportunities for undergraduate faculty at all career stages, awarded on the basis of the potential impact that such support would have on strengthening undergraduate science and mathematics;

- development of mechanisms, including computer networks and regular regional meetings, to link individuals and institutions into new clusters and partnerships to focus on the process of strengthening undergraduate science and mathematics. The institutions should include federal and state agencies, private foundations, business, industry, and schools; and

- expansion of programs that support the infrastructure, buildings, maintenance, facilities, laboratories, computers, and scientific equipment that are vital and important to effective science and mathematics education at the undergraduate level.

These reforms are especially critical for predominantly minority institutions. An increase in the amount and quality of research activity at minority colleges and universities will provide additional opportunities for minority students to become involved in science and mathematics. Faculty and students can benefit from research opportunities at national laboratories, in business and industry, and in state and local governments. Access to such opportunities must be increased and enhanced. Federal and state agencies must expand programs of support for facilities, laboratories, and equipment that will result in effective undergraduate instruction at institutions serving minority students.

Teacher Preparation Programs

The objectives of the MSE Network cannot be achieved without support for innovation and reform in the preparation and in-service enhancement of pre-college teachers and college and university faculty. Instructional programs for pre-college teachers must prepare them to teach all students well, through content-based, hands-on experiences leading to mastery of key science and mathematics concepts, problem- solving skills, and necessary pedagogical skills.

All phases of teacher preparation, including general education, content preparation, professional education, and support for new entrants into the teaching profession need attention. Undergraduate preparation of teachers of mathematics, for example, must meet NCTM standards at the elementary, middle, and high school levels, and content preparation for secondary teachers must equal or exceed that generally required for baccalaureate degrees

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in the area of specialization. Teacher education programs must undertake the preparation of teachers as a partnership, a joint responsibility involving many departments at the college as well as different units and individuals in local school systems, colleges and universities, community colleges, professional organizations, parent and community groups, business, and industry.

Science and mathematics teacher candidates must have early and extensive in-school experiences in a variety of community settings. They must experience science or engineering research firsthand and be well-trained in the use of technology. These are critical components if the nation is to have a teaching corps that is responsive to the community and society it serves, understands the dynamic nature of science and technology, and is able to use technology effectively as a teaching tool. All prospective teachers must be knowledgeable and understanding of the pluralistic nature of society and of their future classrooms. To be effective as teachers of students with a range of cultural backgrounds, their preparation must include a multicultural perspective, including an examination of the issue of historic exclusion of minorities and exclusion from the pursuit of MSE careers.

Percentage of Minority Mathematics and Science Teachers in the Teacher Workforce, 1985-86, by Subject and Grade Range

SUBJECT/ GRADE RANGE	BLACK (%)	HISPANIC (%)	INDIAN (%)
% of U.S. population	**12**	**7.8**	**0.6**
MATHEMATICS			
K-3	10	1	0
4-6	12	2	0
7-9	6	1	0
10-12	3	1	0
SCIENCE			
K-3	9	4	0
4-6	8	4	0
7-9	6	1	0
10-12	5	1	1

Source: *Professional Women and Minorities: A Manpower Data Resource Service*, Commission on Professionals in Science and Technology, Ninth Edition, March 1991

Recruitment of more minority teachers in mathematics, science, and engineering is of major importance. The teaching corps must be culturally and ethnically diverse and representative of society and the communities it serves. Teacher preparation should provide all students with the necessary information and support structures to enter the teaching profession successfully. Teacher education programs should use a variety of strategies to interest more pre-college and undergraduate students in careers in teaching mathematics, science, and engineering.

To attract and nurture minority students at the pre-college level so that they will consider pursuing teaching careers, the MSE Network will:

- promote the early identification and nurturing of students showing interest in mathematics and the sciences through Saturday academies, middle school and high school residential academies, and pre-college-to-college bridge programs;

- promote development of clubs and programs encouraging exploration of teaching careers, such as Future Science and Mathematics Teachers;

- encourage mathematics and science teachers and counselors to promote teaching as a career among students who have demonstrated interest and talent in mathematics and science; and

- promote more opportunities for students, particularly minority students, to serve as tutors to their peers or younger students or as laboratory assistants, thereby helping them to envision themselves in a teaching role.

Financial assistance for prospective minority teachers of mathematics, science, and engineering is a critical need. To ensure a significant increase in the number of minority science and mathematics teachers at the pre-college level, prospective teachers must be able to complete their undergraduate education debt free, through the provision of scholarships, grants, and forgivable loans (when they teach in areas and settings with critical need), paid summer teaching, and research internships.

The underrepresentation of minorities among college faculty remains a serious problem, and the MSE Network recognizes the need for more innovative approaches to this problem. At the undergraduate level, pools of high-ability and high-potential minority students with interest in pursuing an academic career must be identified early and carefully prepared for future tenure-track faculty positions in colleges and universities. Faculty career centers can create secure pathways to the doctoral degree for such undergraduates beginning as early as the end of their sophomore year in college. The students' academic and research performance should be strengthened through well- placed enrichment programs, and the students matched with appropriate faculty and programs to ensure their persistence through graduate school. Business and industry, along with higher educational institutions and government, must also invest in the preparation of graduate students interested in faculty careers.

Minority junior faculty members must be provided research initiation support as they enter tenure-track faculty positions. In addition, all faculty members need support for attendance at professional meetings, professional enhancement or development activities, and sabbatical leaves.

The MSE Network will encourage the development and dissemination of collaborative model programs with these characteristics.

Institutional Development

The nation's minority institutions have consistently out-distanced non-minority institutions in the production of minority baccalaureate graduates in mathematics, science, and engineering. Their role must be recognized and their programs strengthened to ensure an expanded flow of well-prepared undergraduates into graduate school or the work force.

For example, the eight (8) engineering programs at Historically Black Colleges and Universities graduate 25 percent of all of the African American baccalaureate degrees in engineering. Based on such a track record at the undergraduate level, it is clear that minority institutions must play a major role in increasing the number of minorities pursuing graduate degrees in mathematics, science, and engineering. To assume this role, minority institutions must achieve a proper balance between teaching and research. To this end, it is imperative that there be an increase in the number of minority institutions that have strong research-based programs.

Historically, minority institutions have not received adequate funding from external sources to enhance research activities. For example, of the 117 Historically Black Colleges and Universities, approximately 25 are involved in some level of scientific research, with only 10 of these having significant research involvement. Student participation in the research and discovery process is essential to nurturing and sustaining interest in mathematics, science, and engineering and is necessary to the successful encouragement of students to consider and subsequently enroll in graduate programs in those areas.

Collaboration between minority and non-minority institutions is an excellent means of providing research opportunities for both faculty and students at minority institutions. However, this arrangement is, at best, a short-term remedy that does not significantly affect the research infrastructure of predominantly minority institutions. In the long run, research infrastructures must be strengthened in a significant number of minority institutions in order to meet national scientific and technical personnel needs and to achieve the quantitative and qualitative goals of the MSE Network. Here, again, industry can play an important role in providing research experiences for minority faculty and students, while minority institutions develop their research capabilities. Strengthening the research infrastructure of those minority institutions with some existing research capability would be an appropriate starting point.

Graduate, Post-Doctoral, and Research Programs

Gains achieved in minority participation in graduate education in the late 1960s and mid-1970s have not been sustained, and participation has steadily declined over the last decade and a half.

If the nation is to meet its scientific and technological work force needs, it must reverse this trend. It must provide programs to ensure that minority undergraduates are academically prepared to make a smooth transition into graduate school and that financial support for that purpose is readily available.

Colleges and Universities

Colleges and universities must consider minority graduate student recruitment and development a major priority and should make it an institutional goal. Focused efforts are needed that:

- Δ emphasize the benefits of academic life;
- Δ broaden the admissions and funding eligibility criteria of academic departments and programs to recognize a greater variety of factors indicating potential for graduate study success (e.g., recommendations, research experience, personal statements, and interviews);
- Δ place greater emphasis on research and on faculty involvement in mentoring and exposing minority students to opportunities to develop their research capabilities;
- Δ expand accessibility to informational resources;
- Δ assist students in the early identification and understanding of graduate school funding options;
- Δ expand institutional financial support for minority students;
- Δ distribute information about graduate school programs and research opportunities at Historically Black Colleges and Universities (HBCUs), minority institutions (MIs), and major non-minority research universities;

- Δ assign a high priority to expanding the doctoral production capacity of HBCUs/MIs through a variety of means, including linkages to and consortia with major research universities as well as strengthening existing or approved doctoral programs in the sciences at these institutions; and

- Δ significantly increase the investment in plant, equipment, and other capital expenditures that strengthen the research infrastructure at HBCUs/MIs.

Federal Agencies

Federal agencies can support the goals of the MSE Network to assist minority institutions in their quest for increased research training and opportunities for faculty and students and for greater participation by minorities in graduate education by:

- Δ opening and expanding the peer review process to include more input from faculty at minority institutions and by ensuring fairness in funding distribution;

- Δ expanding resources in undergraduate programs to support and encourage minority student participation in research;

- Δ establishing and securing partnerships between institutions, funding agencies, and the private sector to provide research experiences, training, and opportunities to be involved in "cutting edge" research; and

- Δ establishing programs to strengthen science programs at HBCUs/MIs and to support minority graduate MSE education and post-doctoral programs.

Industry and National Laboratories

Industry and national laboratories can lend strong support to the MSE Network's national program by:

- Δ providing internships and research experiences for undergraduate and graduate students, as well as college and university faculty, at minority institutions;

- Δ signing and supporting the achievement of the MSE Network's Statement of Principles and Memorandum of Understanding; and

- Δ placing greater value on and supporting research at HBCUs/MIs.

Private Foundations

Private foundations can assist in achieving the numerical MSE goals of this agenda by:

- providing undergraduate scholarships and graduate fellowships for minority students enrolled at HBCUs/MIs with demonstrated high potential and motivation for MSE study;
- supporting faculty development opportunities for individual MSE faculty at HBCUs/MIs; and
- encouraging and supporting major revisions in introductory courses in MSE fields at the undergraduate level.

The MSE Network

The MSE Network will promote effective involvement of minority constituencies with funding agencies in developing program guidelines and in more successfully responding to those guidelines. It will encourage institutions to identify programs that need development assistance, and it will establish student tracking and resource identification procedures to ensure that every talented minority student interested in and prepared for graduate education will be able to pursue this education without incurring additional personal debt.

Assessment and Evaluation

Systematic evaluation is an essential and pervasive component of this national agenda. The MSE Network will promote assessment and evaluation at both the national and the local levels. It will develop evaluation designs and will facilitate the collection of uniform data, and it will use those data as feedback to propel its program forward.

The evaluation and assessment program of the MSE Network will be designed to: determine the success of the Network in contributing to the achievement of the "numerical goals for the year 2000"; improve program quality; ensure that desired intermediate outcomes are achieved; and identify and replicate successful models. Specifically, the MSE Network will use its evaluations to serve the national need to educate minorities in mathematics, science, and engineering by:

- establishing meaningful criteria for success and encouraging the maintenance of appropriate data items;

- monitoring the state of mathematics, science, and engineering education for minority students nation-wide; and

- identifying and describing successful strategies for attracting, educating, and retaining minorities in mathematics, science, and engineering.

In addition, the MSE Network will use this evaluation to serve the internal needs of the Network by:

- setting goals that are reasonable, obtainable, and measurable;

- obtaining baseline data, at the local, state, and national levels, that will provide a longitudinal tracking system for participants and programs, against which the effects of Network intervention can be identified and assessed;

- developing, in consultation with various MSE Network Topic Committees, objectives that will identify both cognitive and affective outcomes in the following areas: K-12, undergraduate and graduate education; college and university faculty enhancement; and career and professional development;

- establishing quantitative and qualitative evaluation criteria to measure attainment of these objectives;

- ensuring the integrity and security of the data and the validity of conclusions drawn from them; and

- making or updating recommendations on the viability, effectiveness, transportability, and cost efficiency of Network programs.

OVERVIEW

A NATIONAL STRATEGY TO HELP ACHIEVE THE NUMERICAL MSE GOALS FOR THE YEAR 2000

NUMERICAL GOALS[1]

- Quadruple the number of minority students receiving MSE baccalaureate degrees annually from about 17,000 in 1987 to 68,000 by the year 2000
- Triple the number of minorities receiving MSE doctorates annually from 389 in 1987 to about 1200 by the year 2000
- Quintuple the number of minority college students newly qualified to teach who enter teaching each year from about 6,000 in 1986 to 30,000 by the year 2000, with at least 30% of this group being mathematics and science pre-college teachers

CHARACTERISTICS OF THE NATIONAL STRATEGY

- It places predominantly minority institutions in leadership roles
- It involves networking around successful or promising educational strategies at several levels:
  - across entities (educational institutions and organizations, community groups, business and industry, and government)
  - in different settings (local, state, regional, and national)
  - along all segments of the educational pipeline
- It requires a comprehensive communications system (utilizing various media and a wide area computer network)
- It provides for extensive formative and summative evaluation

[1] **As defined in *"TOGETHER WE CAN MAKE IT WORK" April 1992 and in the QEM Report: "EDUCATION THAT WORKS: AN ACTION PLAN FOR THE EDUCATION OF MINORITIES" January 1990.***

MAJOR ELEMENTS OF THE NATIONAL STRATEGY

- Replication and networking of existing successful early intervention strategies such as Saturday Science Academies for students in grades 3-8
- A national network of Summer Residential Science Academies for low-income and minority students from grades 7 - 12 who would participate each of the six summers to ensure that they receive quality science and mathematics preparation
- Replication of successful pre-freshman summer, freshman year, and second summer programs to ensure continued motivation for and persistence in MSE
- A national network of faculty career centers as collaborative ventures between minority and non-minority institutions to ensure secure pathways for MSE-talented college sophomores through the Ph.D., and into academic and research careers
- A national network of teacher preparation and enhancement centers at predominantly minority institutions to strengthen their teacher preparation and in-service programs with a special emphasis on hands-on activities and the use of educational technology

MAJOR IMPLEMENTATION MECHANISMS OF THE NATIONAL STRATEGY

- Establishment of a formal national networking organization (the MSE Network) of minority and non-minority institutions, school systems with large minority populations, business and industry, and government as a vehicle for implementing the national strategy
- Creation of a student tracking and information system for promising minority mathematics and science students to:

  provide these students with course and career information to (1) help ensure their continued participation in, and motivation for, MSE fields; and (2) make them aware of available financial assistance for MSE students at the undergraduate and graduate levels

  maintain information on their academic decisions and progress to provide feedback on the effectiveness of various intervention strategies
- The conduct of a series of workshops focusing on leadership development, proposal development, and project evaluation to strengthen the ability of colleges and universities, school systems, and community organizations to organize, obtain support for, and document their efforts to implement the major elements of the national strategy in their community, state, or region
- Dissemination of information to minority communities on informal science education opportunities such as science museums, internships, science education television programs, and exemplary science educational materials

Estimated Costs

Estimates represent the direct costs associated with implementing the three numerical goals of *Together We Can Make It Work* by providing summer and academic year experiences to selected pools of students. They do not include estimates for strengthening mathematics, science, and engineering programs at Historically Black Colleges and Universities and predominantly minority institutions. These additional estimates will be available following an assessment of their needs. Costs associated with increasing the number of minority students receiving baccalaureate degrees in the physical and life sciences and in engineering focus on preparing pre-college students in mathematics and science through enrichment activities such as Saturday science academies, visits to science museums, high school research apprenticeships, and summer residential and commuting science academies. At the undergraduate level, students are provided "hands-on" research experiences during the academic year and summer.

Increasing the number of minority students receiving mathematics, science, and engineering baccalaureate degrees is integral to achieving two other objectives—increasing the number of Ph.D.s and the number of mathematics and science teachers. The new science and engineering baccalaureates will, eventually, form the "pool" from which graduate students and teacher candidates will be drawn. Since *Together We Can Make It Work* calls for increasing numbers, the associated costs are new monies. The following assumptions were made in estimating costs:

- Annual per student cost for students in grades 7 and 8 is $1200
- Annual per student cost for students in grades 9 through 12 is $2500
- Annual per undergraduate student cost is $7500 (a $5000 scholarship plus a $2500 summer research stipend) for freshmen, sophomores, juniors, and seniors
- Annual per graduate student cost is $21,000 ($14,000 fellowship plus $7500 cost of education allowance) for six years
- No additional costs will be incurred for cohorts of juniors entering the pool beginning in 1999 because the 1993 cohort of high school sophomores will become the new pool for Ph.D. candidates
- Modest efforts will begin in 1993 to attract new teacher candidates from among college sophomores; however, the major pool of sophomore teacher candidates appears in 1998 when the 1993 cohort of high school sophomores will be college sophomores
- Annual cost per teacher candidate is $7500,(a $5000 scholarship plus $2500 toward undergraduate loan forgiveness) for the junior and senior years in college. The year for credentialling following graduation from college is estimated at a cost of $12,000

The following tables summarize the strategies to be used and the estimated costs.

SUMMARY OF STRATEGIES TO BE USED AND ESTIMATED COSTS TO ACHIEVE THE THREE NUMERICAL GOALS BY THE YEAR 2000

Numerical Goals	Extra Degrees Needed Yearly	Target Groups	Est. Costs (Bills)
Goal 1: Quadruple the number of baccalaureate degrees awarded annually in the physical and life sciences and engineering	51,000*	Ideally, students targeted for programs leading to a BS in mathematics, science, or engineering would begin participating in special enrichment activities no later than grade 7. However, the students who will be graduating from college in the year 2000 will be entering grade 9 in the 1992-93 school year. Therefore, 9th grade students will be targeted in the initial year while also starting programs for 7th and 8th graders.	$16.64*
Goal 2: Triple the number of doctorates annually in the physical and life sciences, and engineering	800	To achieve this goal beginning in 2000, it will be necessary to target a pool of highly talented MSE undergraduates entering their junior year in the 1992-93 school year to allow six years of study from the baccalaureate to the Ph.D. degree. Secure pathways will be developed for each student in the pool, including • undergraduate research opportunities each summer as well as during the academic year; • undergraduate scholarship assistance; and assuming direct entry into a doctoral program; • a combination of fellowships and research assistantships for six years, assuming full-time enrollment and steady progress toward the degree; and a • tenure-track faculty position when the degree is obtained.	$0.57
Goal 3: Quintuple the number of minority college students entering precollege teaching each year, at least 30% of whom are mathematics and Science teachers	7200	The pool of S&E pre-college teachers will be drawn from the MSE baccalaureate degree students being developed with activities related to the first goal. Therefore, most of the additional costs for achieving this goal are associated with teaching incentives such as • forgivable undergraduate degree loans; • leadership development seminars; and • training in the use of advanced technologies in the classroom.	$0.75
TOTALS	**51,000** **800** **7,200**		**$17.96** **(1993- 2000)**

* - Approximately 1,056,000 students will be impacted. They will be distributed over 10 grade levels (7th grade through the senior year in college).

ESTIMATED ANNUAL COSTS FOR IMPLEMENTATION OF ACTIVITIES TO ACHIEVE THE THREE NUMERICAL GOALS , (1993 - 2000) ($ in Billions, rounded)									
GOAL	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
1. BS Degrees	$.67	$.95	$1.22	$1.50	$2.25	$2.88	$3.39	$3.77	$16.64
2. Ph.D.s	.01	.02	.05	.07	.09	.10	.11	.12	.57
3. Teachers	.01	.02	.03	.04	.06	.15	.19	.26	.75
TOTAL	$.69	$.99	$1.30	$1.61	$2.40	$3.13	$3.69	$4.15	$17.96

Next Steps

In keeping with the Network's Memorandum of Understanding, MSE Network members will collaborate with each other and with non-members on programs to ensure that minority students receive rigorous preparation in mathematics and science at the pre-college level and that they receive timely information about various science-based careers and their academic requirements. Students in these programs demonstrating high potential and interest in mathematics and science will be provided enriching after school, Saturday, and summer experiences, including summer science residential and commuting academies, that focus on science, mathematics, the use of technology, and both oral and written communications. These efforts will build upon outreach activities existing at member institutions, including those supported through various federal agency programs (for example, the National Science Foundation's Career Access Program and its Alliances for Minority Participation Program as well as the Department of Education's Minority Science Improvement Program).

Members will seek additional support to strengthen the mathematics, science, and engineering programs at Historically Black Colleges and Universities and predominantly minority institutions. Needs assessments will be conducted to determine areas that require new resources. In this regard, a particular focus will be placed on existing or planned mathematics, science, and engineering graduate degree granting programs such as those that receive support from the National Institutes of Health's Minority Biomedical Research Program and its Research Centers of Excellence Program as well as the National Science Foundation's Minority Centers of Excellence Program.

Linkages will be formed among member and non-member minority institutions, non-minority institutions, national and federal laboratories, and business and industry to ensure that their mathematics, science, and engineering students have supplemen-

tary, enriching experiences to enable them to directly enter and succeed in graduate school or the workplace. Various science consortia and research programs supported through the Department of Energy, the national laboratories, the Department of Defense, and the National Aeronautics and Space Administration will be examined as possible models for other collaborative efforts.

Collaborations will be formed among members and non-members, professional societies, teacher and teacher education organizations and associations, and federal agencies and private foundations with a special interest in the preparation and leadership development of mathematics and science teachers (for example, the Ford Foundation, the Annenberg CPB Project, the DeWitt-Wallace Reader's Digest Fund, the Kellogg Foundation, and the AT&T Foundation).

The Network will consider several factors within each state in which members are located to determine the state's potential to contribute to achieving the numerical goals of *Together We Can Make It Work*. Individual state action plans will be developed, based upon this analysis and will be coordinated with other state initiatives such as the National Science Foundation's State Systemic Initiative.

An early audience will be sought with the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET)'s Committee on Education and Human Resources to discuss *Together We Can Make It Work* and to solicit their support for its goals. Similar meetings will be held with program officers at various science-oriented agencies and private foundations with minority science improvement programs (for example, the David and Lucile Packard Foundation, the Pew Charitable Trusts, and the Howard Hughes Medical Institute). These efforts will be aimed at identifying potential sources of funding for implementing *Together We Can Make It Work* and for developing a funding base to support the various projects and activities of the MSE Network.

The MSE Network will identify, endorse, link, and expand exemplary strategies to facilitate the accomplishment of its numerical objectives. These strategies will be added to the QEM Network's database of promising programs so that they will be accessible to members and to others interested in ensuring quality mathematics, science, and engineering programs for minority students. Directors of successful approaches will be invited to share their work with others at the annual February meeting of the MSE Network.

Together
We Can Make It Work

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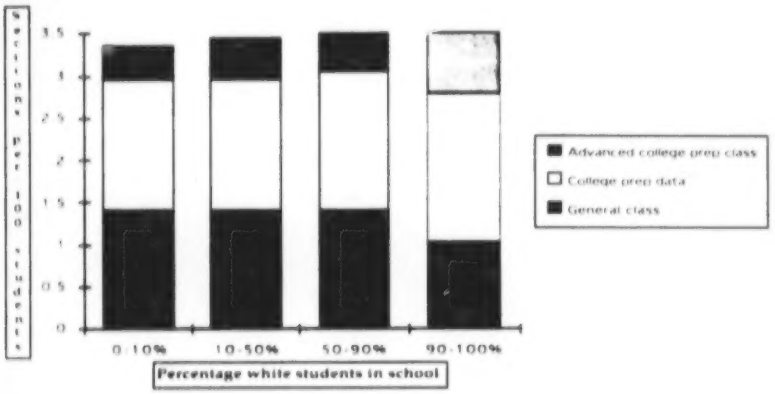
Supporting Tables and Charts

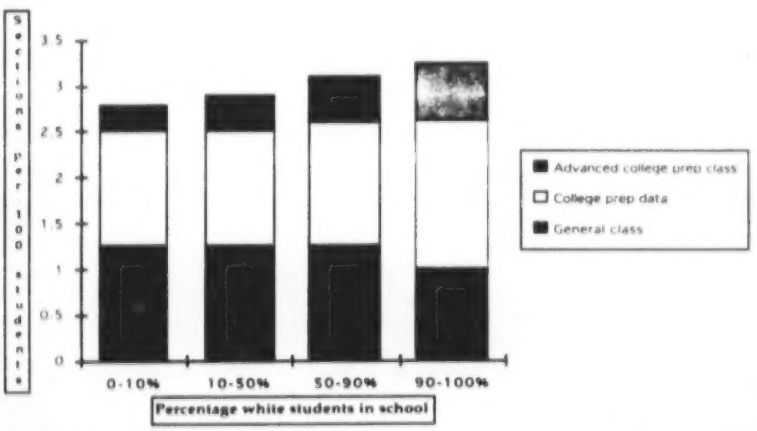
TABLE 1
SECTIONS OF MATHEMATICS AND SCIENCE CLASSES IN HIGH SCHOOLS, BY RACIAL COMPOSITION OF STUDENT BODY: 1986

MATHEMATICS



% white students in school	0-10%	10-15%	50-90%	90-100%
General class	1.4	1.4	1.4	1.0
College prep data	1.55	1.55	1.65	1.75
Advanced college prep class	0.4	0.5	0.45	0.73

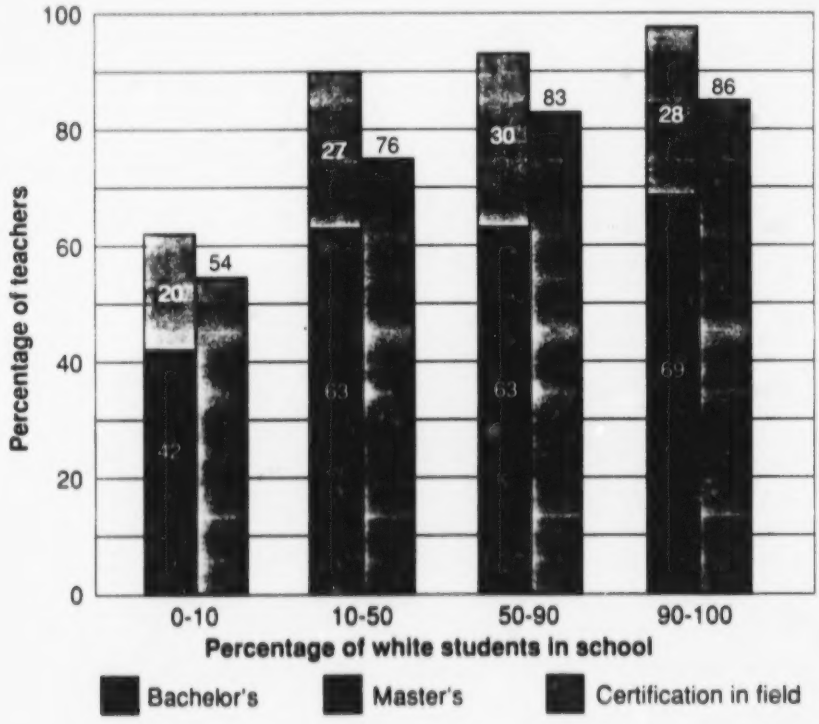
SCIENCE



% white students in school	0-10%	10-15%	50-90%	90-100%
General class	1.25	1.25	1.25	1.0
College prep data	1.25	1.25	1.35	1.6
Advanced college prep class	0.3	0.4	0.5	0.65

Source: J. Oakes, Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science (Santa Monica, CA: The RAND Corporation, 1990).

TABLE 2
DEGREES AND CERTIFICATION OF SCIENCE AND MATHEMATICS SECONDARY SCHOOL TEACHERS, BY SCHOOL RACIAL COMPOSITION: 1987



	Percentage of teachers			
% white students in school	0-10%	10-15%	50-90%	90-100%
Bachelor's	42	63	63	69
Master's	20	27	30	28
Certification in field	54	76	83	86

Source: J. Oakes, Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science (Santa Monica, CA: The RAND Corporation, 1990).

TABLE 3
Achievement Test Scores in Science and Mathematics for College-bound Seniors, by Racial/Ethnic Group: 1991

ACH AND SAT MATH	TOTAL	WHITE	BLACK	ASIAN	NATIVE AMER	MEXICAN AMER	PUERTO RICAN
CHEMISTRY	575	577	503	586	525	516	504
SAT-MATH	645	646	557	661	600	591	584
BIOLOGY	561	565	496	562	509	497	503
SAT-MATH	601	602	513	622	551	534	519
PHYSICS	601	603	533	606	561	522	534
SAT-MATH	668	670	592	682	631	595	594
MATH LEVEL 1	549	554	486	573	509	481	505
SAT-MATH	569	578	494	584	530	483	519
MATH LEVEL II	666	667	596	682	636	599	627
SAT-MATH	654	658	576	662	631	574	610

Source: Admissions Testing Program of the College Entrance Examination Board, College Bound Seniors, 1991 Profiles of SAT and Achievement Test Takers, (Princeton, NJ: Educational Testing Service, 1991) p.11

TABLE 4
Average Advanced Placement Test Grades in Science and Math Fields, by Racial/Ethnic Group: 1990

ADVANCED PLACEMENT TEST FIELDS	TOTAL	WHITE	BLACK	ASIAN	NATIVE AMER	MEXICAN AMER	PUERTO RICAN
BIOLOGY	2.96	2.97	2.07	3.17	2.50	2.20	2.41
CHEMISTRY	2.94	2.93	1.96	3.20	2.20	2.10	2.49
PHYSICS B	2.80	2.79	2.05	2.97	2.04	2.13	2.42
PHYSICS C-MECHANICS	3.36	3.38	2.44	3.49	2.13	2.45	2.82
PHYSICS C-ELEC&MAG	3.32	3.33	2.75	3.34	1.50	2.65	2.42
MATH/CALCULUS AB	3.23	3.24	2.31	3.43	2.51	2.72	2.79
MATH/CALCULUS BC	3.65	3.65	3.08	3.72	3.52	3.18	3.20
COMP. SCIENCE AB	2.81	2.88	2.04	2.74	2.23	2.25	2.05
COMP. SCI. A	2.92	3.00	1.80	2.94	2.50	1.94	2.07

Grading Scale: 1 = no recommendation for college credit; 2 = possibly qualified; 3 = qualified; 4 = well qualified; and 5 = extremely well qualified.

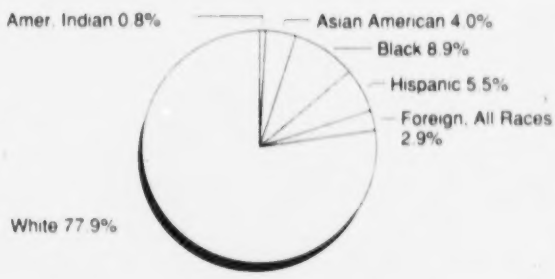
Source: Advanced Placement Program of the College Entrance Examination Board, 1990 Advancement Placement Program, National and District of Columbia Summary Reports (Princeton, NJ: Educational Testing Service, 1990) pp. 3-5.

TABLE 5
Intended Undergraduate Majors and Corresponding SAT Mathematics Score of College-bound Seniors with Interest in Science and Engineering by Racial/Ethnic Group: 1991

INTENDED AREA OF COLLEGE STUDY	TOTAL	WHITE	BLACK	ASIAN	NATIVE AMER	MEXICAN AMER	PUERTO RICAN
% OF INTENDED MAJORS							
BIOLOGICAL SCIENCE	4	4	3	5	4	3	4
COMPUTER SCIENCE	3	2	7	4	3	3	4
ENGINEERING	10	10	11	17	9	12	12
MATHEMATICS	1	1		1	1	1	
PHYSICAL SCIENCE	1	2	1	2	1	1	1
SAT MATH SCORES							
BIOLOGICAL SCIENCE	512	518	417	571	452	457	437
COMPUTER SCIENCE	467	508	368	530	424	408	382
ENGINEERING	548	569	442	581	503	490	459
MATHEMATICS	605	616	489	630	575	530	547
PHYSICAL SCIENCE	572	577	457	620	527	496	482

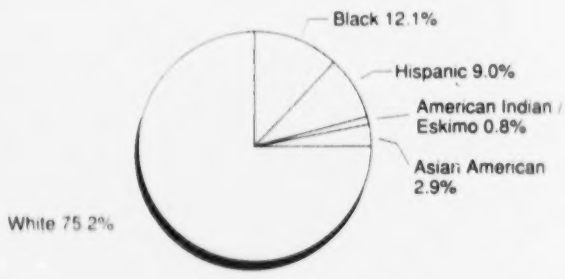
Source: Admissions Testing Program of the College Entrance Examination Board, College Bound Seniors, 1991 Profiles of SAT and Achievement Test Takers, (Princeton, NJ: Educational Testing Service, 1991) p.8

Enrollment in Higher Education, by Racial and Ethnic Group, 1990



Source: Chronicle of Higher Education, March 18, 1992, p. A35

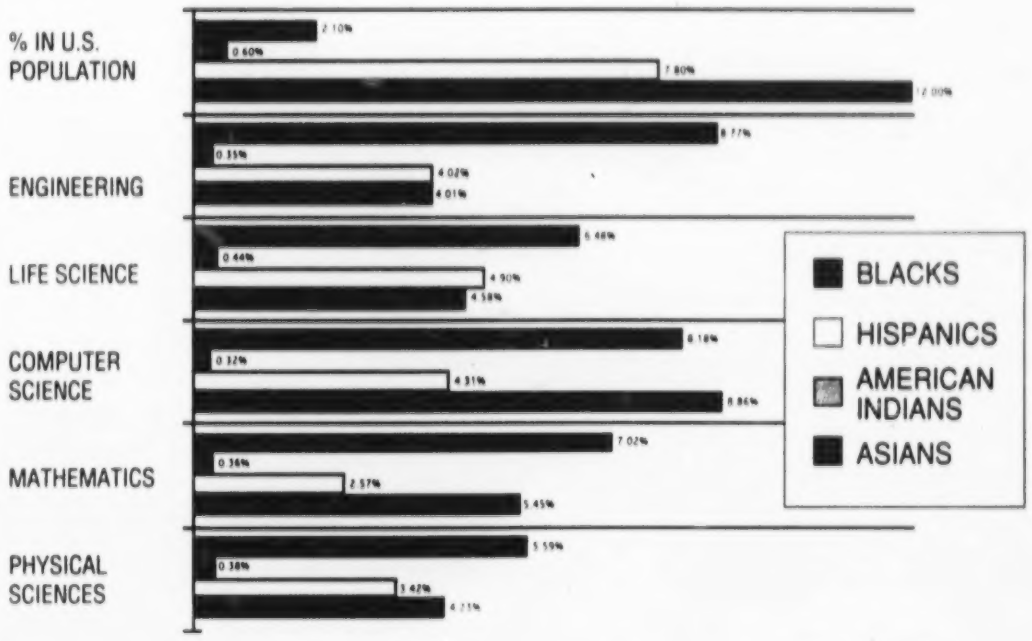
Percent in U.S. Population, by Race (1990)



Source: 1990 Census Profile, Number 2 — June 1991, U.S. Department of Commerce, p. 2

TABLE 6
Number and Percentage of Minority Baccalaureate Degree Attainment in Selected Disciplines, 1989 vs. U.S. Population, 1986

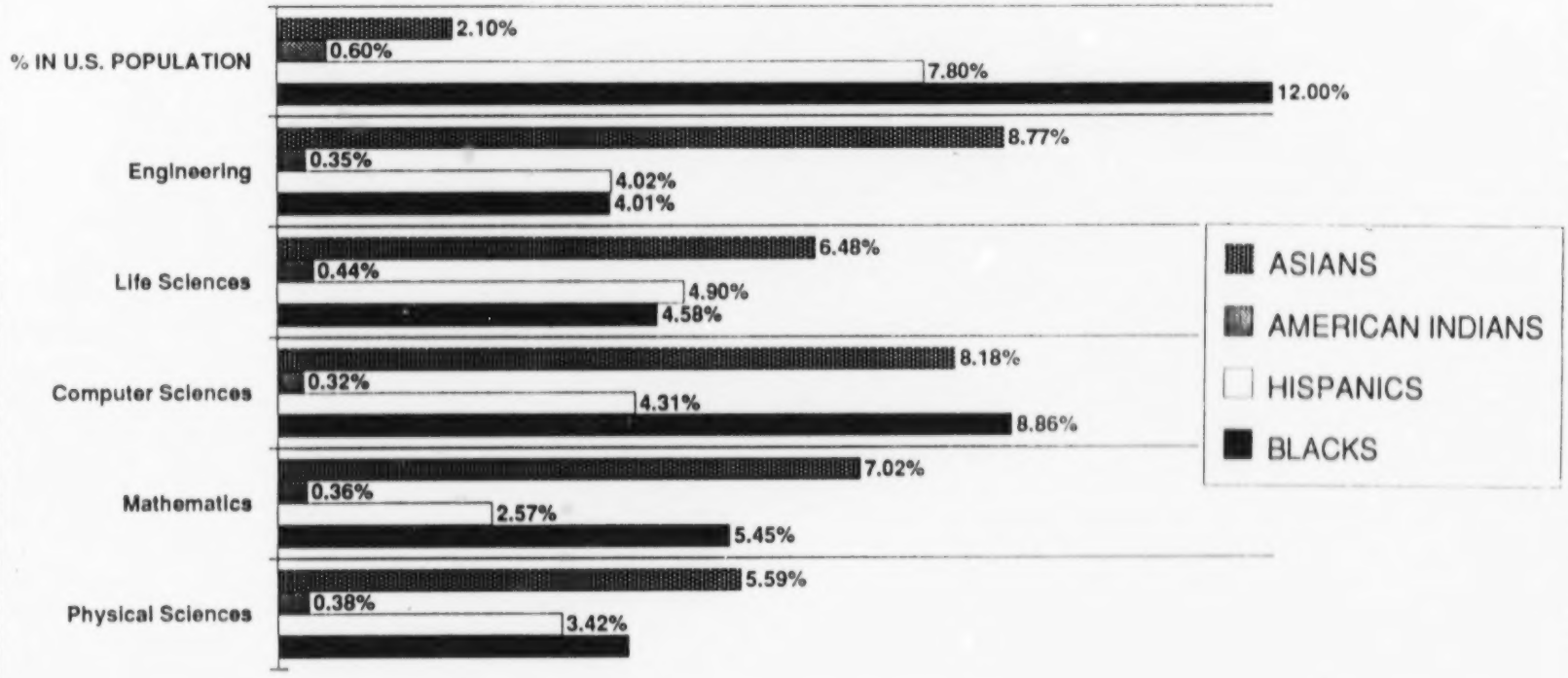
FIELD OF STUDY	TOTAL DEGREES AWARDED	BLACKS	HISPANICS	AMERICAN INDIANS	ASIANS
Physical Sciences	16,482	697	563	62	922
Mathematics	14,524	792	373	53	1,019
Computer Sciences	27,721	2,457	1,195	90	2,268
Life Sciences	48,561	2,225	2,381	215	3,146
Engineering	78,725	3,154	3,168	275	6,903
	% DEGREES AWARDED	BLACKS	HISPANICS	AMERICAN INDIANS	ASIANS
Physical Sciences	100	4.23%	3.42%	0.38%	5.59%
Mathematics	100	5.45%	2.57%	0.36%	7.02%
Computer Sciences	100	8.86%	4.31%	0.32%	8.18%
Life Sciences	100	4.58%	4.90%	0.44%	6.48%
Engineering	100	4.01%	4.02%	0.35%	8.77%
% IN U.S. POPULATION		**12.00%**	**7.80%**	**0.60%**	**2.1%**



Source: National Science Board, Science and Engineering Indicators, 1991, Tenth Edition, p. 236

CORRECTION TO CHART FOR TABLE 6 - page 38*

Number and Percentage of Minority Baccalaureate Degree Attainment in Selected Disciplines, 1989 vs. U.S. Population, 1986



Source: National Science Board, Science and Engineering Indicators, 1991, Tenth Edition, p.236

* Due to an error in printing, the inks used to reflect the statistics for Blacks and Asians were identical. This insert reflects the corrected chart.

TABLE 7
NUMBER OF SCIENCE* AND ENGINEERING DEGREES REQUIRED TO ACHIEVE PARITY IN DEGREE PRODUCTIVITY IN THE PHYSICAL AND LIFE SCIENCES, AND IN ENGINEERING FOR BLACKS, HISPANICS, AND AMERICAN INDIANS

	TOTAL	BLACKS	HISPANICS	AMERICAN INDIANS
% in 1986 U.S. Population	100%	12.0%	7.8%	0.6%
# BACHELOR'S Earned in 1989	Sci 107,288 Eng 78,725	Sci 6,171 Eng 3,154	Sci 4,512 Eng 3,168	Sci 420 Eng 275
Required for Parity		Sci 12,875 Eng 9,447	Sci 8,368 Eng 6,141	Sci 644 Eng 472
% increase Required for parity		Sci 109% Eng 200%	Sci 85% Eng 94%	Sci 53% Eng 72%
GRADUATE STUDENTS in 1989	Sci 117,880 Eng 71,172	Sci 3,715 Eng 1,810	Sci 3,348 Eng 1,955	Sci 312 Eng 157
Required for Parity		Sci 14,136 Eng 8,605	Sci 9,195 Eng 5,594	Sci 707 Eng 430
% increase Required for parity		Sci 281% Eng 375%	Sci 175% Eng 186%	Sci 127% Eng 174%
MASTERS Earned in 1989	Sci 19,163 Eng 16,362	Sci 512 Eng 401	Sci 477 Eng 477	Sci 86 Eng 35
Required for Parity		Sci 2,300 Eng 1,963	Sci 1,495 Eng 1,276	Sci 115 Eng 98
% increase Required for parity		Sci 394% Eng 390%	Sci 213% Eng 168%	Sci 34% Eng 180%
DOCTORATES Earned in 1990	Sci 7,567 Eng 2,303	Sci 90 Eng 40	Sci 209 Eng 53	Sci 12 Eng 4
Required for Parity		Sci 908 Eng 276	Sci 590 Eng 180	Sci 45 Eng 14
% increase Required for parity		Sci 908% Eng 590%	Sci 182% Eng 240%	Sci 275% Eng 250%

Source: Prepared using information from National Science Board, Science and Engineering Indicators, 1991, Tenth Edition. NOTE: (All information is for U.S. Citizens and Permanent Residents Only)

** - Physical and Life Sciences, and Engineering Only*

TABLE 8
ENROLLMENT IN HIGHER EDUCATION BY RACIAL AND ETHNIC GROUP 1980 AND 1990
(in thousands, 000s)

	1980				1990				
LEVEL	ALL	Under Graduate	Graduate	Professional	ALL	Under Graduate	Graduate	Professional	10-yr diff.
ALL	12,087	10,560	1,250	277	13,710	11,863	1,574	274	13%
American Indian	84	79	4	1	103	95	6	1	23%
Black American	1,107	1,028	66	13	1,223	1,124	84	16	10%
Hispanic American	472	438	27	7	758	702	46	10	61%
Asian American	286	253	28	6	555	485	52	18	94%
White American	9,833	8,556	1,030	248	9,231	10,675	1,221	222	9%
Foreign, All Races	305	208	94	3	397	226	165	5	30%

Source: Chronicle of Higher Education, March 18, 1992, p. A35.

TABLE 9
NUMBER OF POSTDOCTORAL SCIENTISTS AND ENGINEERS, BY RACIAL/ETHNIC GROUP
(In Selected Years, 1977 - 1989)

YR: 1977	TOTAL	BLACK	HISPANIC	NATIVE AMERICAN	WHITE	ASIAN
TOTAL, SCIENTISTS & ENGINEERS	9,755	104	136	–	8,175	1,354
Scientists, total	9,353	99	135	–	7,934	1,211
Engineers, total	402	5	1	–	241	143
YR: 1987						
TOTAL, SCIENTISTS & ENGINEERS	12,296	233	283	24	10,112	1,853
Scientists, total	11,677	220	260	24	9,796	1,598
Engineers, total	619	13	23	0	343	255
YR: 1989						
TOTAL, SCIENTISTS & ENGINEERS	14,760	214	469	34	12,046	2,352
Scientists, total	14,109	188	459	34	11,756	2,025
Engineers, total	651	26	10	0	290	327

– Too few cases to estimate

Source: National Science Foundation, Division of Science Resources Studies, Survey of Doctorate Recipients, Unpublished tabulations.

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Chronology of the MSE Network

April 12-14, 1991. With support from the National Science Foundation, the National Institutes of Health, the National Aeronautics and Space Administration, and the Department of Energy, QEM Network hosted a working conference at which 31 Historically Black Colleges and Universities (HBCUs) and Predominantly Minority Institutions (PMIs) were represented. The working conference approved a Memorandum of Understanding and By-Laws for QEM Network to host the Quality Education for Minorities in Mathematics, Science, and Engineering (MSE) Network. The working conference also prepared a draft Statement of Purpose and Principles.

May 9, 1991. QEM Network invited HBCUs and PMIs to become charter members of the MSE Network. Affiliate membership invitations were extended later to public school systems, major research universities, professional organizations, colleges, and universities in states that have MSE Network members.

September 13, 1991. MSE Network Steering Committee met on Capitol Hill and held a signing ceremony to inaugurate the MSE Network.

December 13-15, 1991. Planning committee prepared the first draft of the MSE Network's national agenda to increase minority participation in mathematics, science, and engineering careers, based on the draft Statement of Purpose and Principles.

February 7-9, 1992. First Annual National Conference of the MSE Network was held in Washington, DC. Participants reviewed and modified the draft national agenda and developed action plans for the MSE Network's Topic Committees.

March 9, 1992. Publications Topic Committee completed its draft of *Together We Can Make It Work: A National Agenda to Provide Quality Education for Minorities in Mathematics, Science, and Engineering*.

April 8, 1992. Release of *Together We Can Make It Work*, Washington, D.C.

About the QEM Network

The **Quality Education for Minorities (QEM) Network** was established in July 1990, as a non-profit organization in Washington, D.C., dedicated to improving education for minorities throughout the nation. Operating with an initial grant from the Carnegie Corporation of New York, the QEM **Network** began where the MIT-based QEM **Project** left off. It is a focal point for the implementation of strategies to help realize the vision and goals set forth in the QEM Project's report: **Education That Works: An Action Plan for the Education of Minorities.**

The QEM Network serves as a national resource and catalyst to help unite and strengthen educational restructuring efforts to the benefit of minority children, youth, and adults. While advancing minority participation and leadership in the national debate on how best to insure access to a quality education for all citizens. It seeks to put into practice the recommendations in the QEM Action Plan by working with minority and non-minority individuals, organizations, and government around the country, to help coordinate and energize efforts to improve the education of minorities.

Based on the "Goals for the Year 2000" set forth in the report **Education That Works**, the QEM Network aims to:

- Serve as a national information and communications network that will collect and widely disseminate information on issues, policies, programs, and resources related to the education of minorities;
- Assist communities across the country in building state and local alliances to meet the educational needs of minority students;
- Monitor and evaluate legislation, policies, and practices as they affect the education of minority students;
- Promote and disseminate information on promising research results on the education of minorities, and serve as a resource in evaluating educational programs and projects;
- Stimulate and assist in the development of programs to increase the number of minorities in science and engineering fields; and
- Implement a series of projects in areas of special interest to develop model approaches for improving education for minorities.

The **QEM Network** employs an extensive networking and coalition building approach. One level of effort is focused on the national education scene. The other is directed towards helping local groups, organizations, and institutions to develop the capacity to mobilize their communities around needed educational improvements.

SEPTEMBER 13, 1991 SIGNING CEREMONY
QUALITY EDUCATION FOR MINORITIES IN MATHEMATICS, SCIENCE, AND ENGINEERING NETWORK
MEMORANDUM OF UNDERSTANDING AND INTENT

The United States is fast becoming a nation of minorities. Scientists and engineers must be drawn from minority communities in increasing numbers, if the U.S. is to maintain its competitive economic position in the world. This can only be done by restructuring the process that produces the nation's minority scientists and engineers.

The purpose of this Memorandum of Understanding and Intent is to combine the efforts of the participating institutions to carry out major mathematics, science, and engineering (MSE) education reform by:

a) Bringing together institutions, organizations, and individuals to promote quality MSE education for minorities;
b) Sharing and disseminating information on the MSE education of minorities;
c) Recommending systemic changes that will improve MSE education for minorities; and
d) Developing a national agenda of programs and projects to improve MSE educational opportunities for minority children, youth, and adults.

This Network will become a national resource through collaboration among the participating institutions as well as between the Network and federal and state agencies; national and federal laboratories; industry, including small businesses; nonminority universities; two-year and four-year colleges; school systems; community groups; and other organizations interested in the MSE education of underrepresented minorities.

Through this Memorandum of Understanding and Intent (MOU) the institutions listed herein establish a Network to develop and promote a national agenda for restructuring the process that produces the nation's minority scientists and engineers.

The principal components of the MOU are that:

1. The Network institutions will collaborate in developing a national agenda for increasing minority participation in mathematics, science, and engineering.
2. The participating institutions will work together to achieve significant levels of federal funding to implement the national agenda.

In order to implement the national agenda for increasing minority participation in mathematics, science, and engineering fields at their own institutions, the Network institutions will:

3. Collaborate in and enhance the development of pre-college, undergraduate, and graduate mathematics, science, and engineering curricula and/or research programs for each institution.
4. Share resources such as faculty and scientific equipment to strengthen individual institutions and the Network as a whole.
5. Individually or jointly collaborate with local pre-college schools to develop and enhance MSE education programs at the pre-college level.
6. Individually or in collaboration develop linkages with other institutions of higher education.
7. Develop individually or jointly, linkages with national and federal laboratories.
8. Develop individually or jointly, linkages with business and industry.
9. Assist, as appropriate, federal and state agencies, national and federal laboratories, school systems, and industry in the recruitment of minority scientists and engineers for regular employment and internship programs.
10. Develop individually or jointly, linkages with professional societies and associations, and other outreach groups to promote public interest, awareness, knowledge, and understanding of issues relate to the MSE education of minorities.
11. Identify sources of funding and develop a funding base to support the activities of the MSE Network.
12. Develop and approve By-Laws to provide the organizational structure and implementation of the goals and objectives herein enumerated.

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